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QVT-Based Model Transformation Using XSLT

Dan LI, Xiaoshan LI

Faculty of Science and Technology, University of Macau

Volker Stolz

University of Oslo, Norway
International Institute for Software Technology, UNU

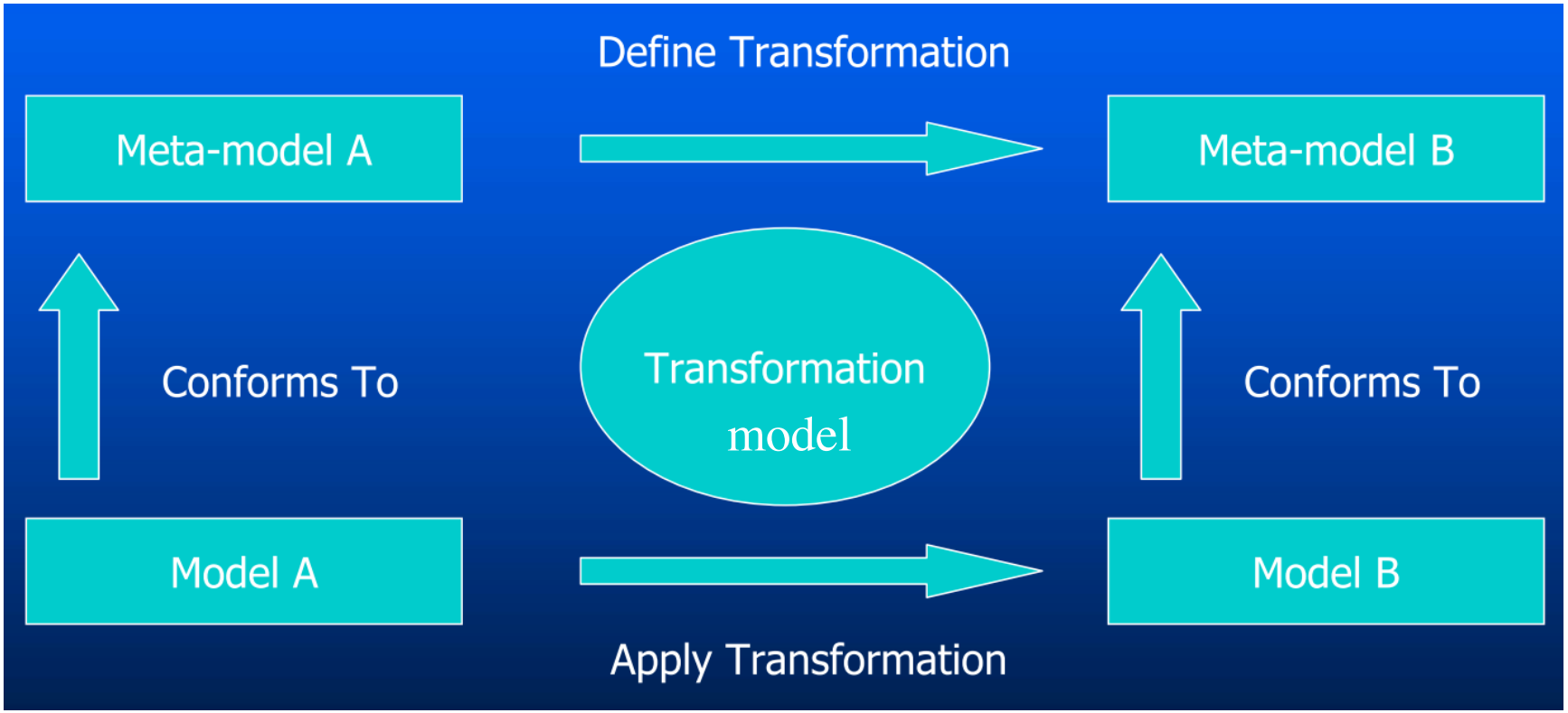
Motivation

- Graphical notation of QVT Relations (QVTR) provides a concise, intuitive way to specify model transformations.
  - But there is NO practical support tool.
- XSLT is a powerful and widely used language with many industrial-strength processors.
  - But programming in XSLT is difficulty during to its low level syntax
- QVTR-XSLT: a practical model transformation framework that combines the power of graphical notation of QVTR and XSLT

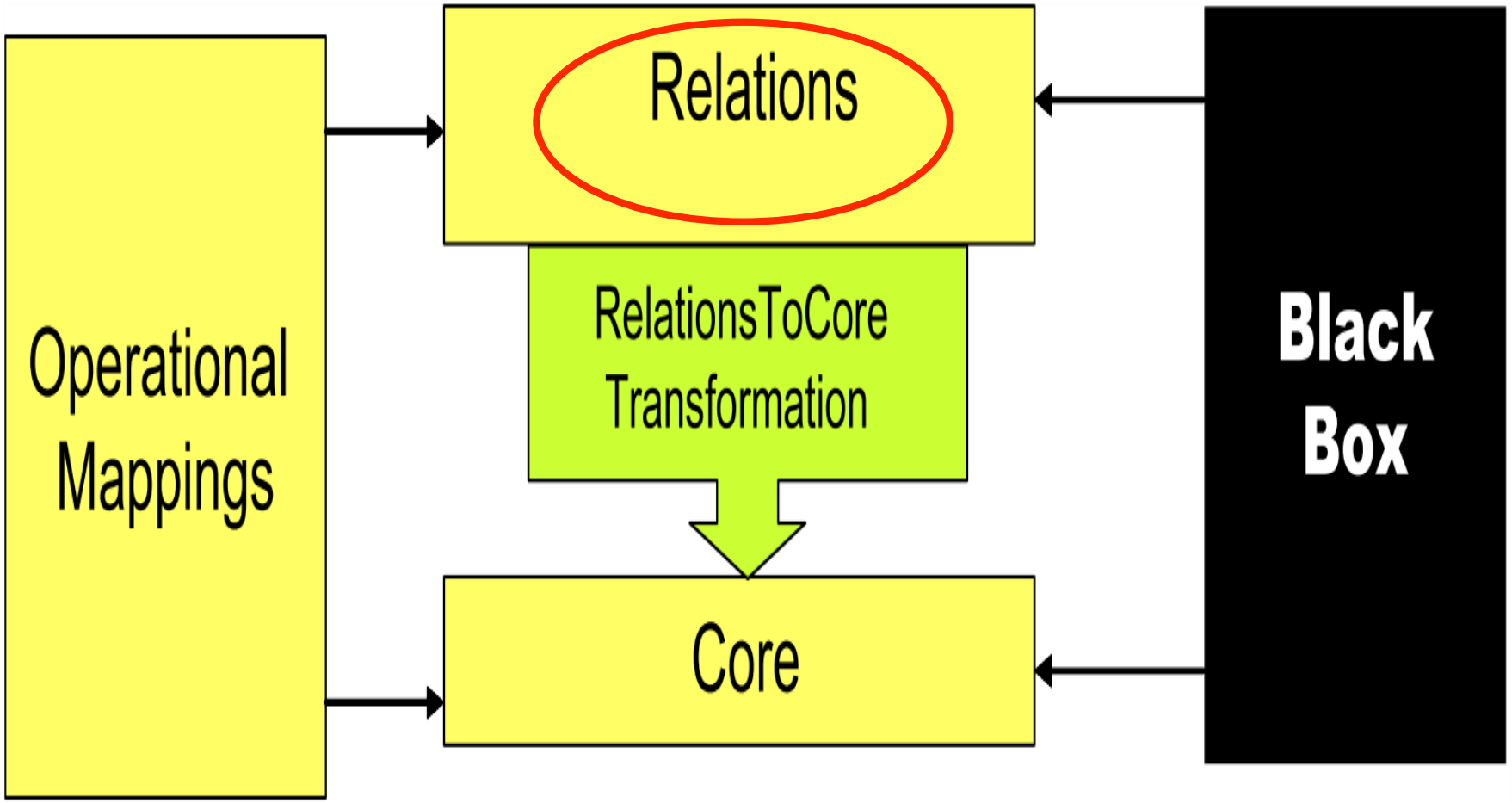
MDA : Model Driven Architecture

- OMG's standards for model-driven development. The core notion includes:
  - Metamodeling – defining models
    - — MOF : Meta Object Facility
      - Simple class diagrams to define abstract syntax and
      - OCL to define static semantics
  - Model Transformation – manipulating models
    - — QVT : MOF 2.0 *Query*, *View*, and *Transformation* language

Model Transformation



QVT Overview



(Taken from the QVT specification)

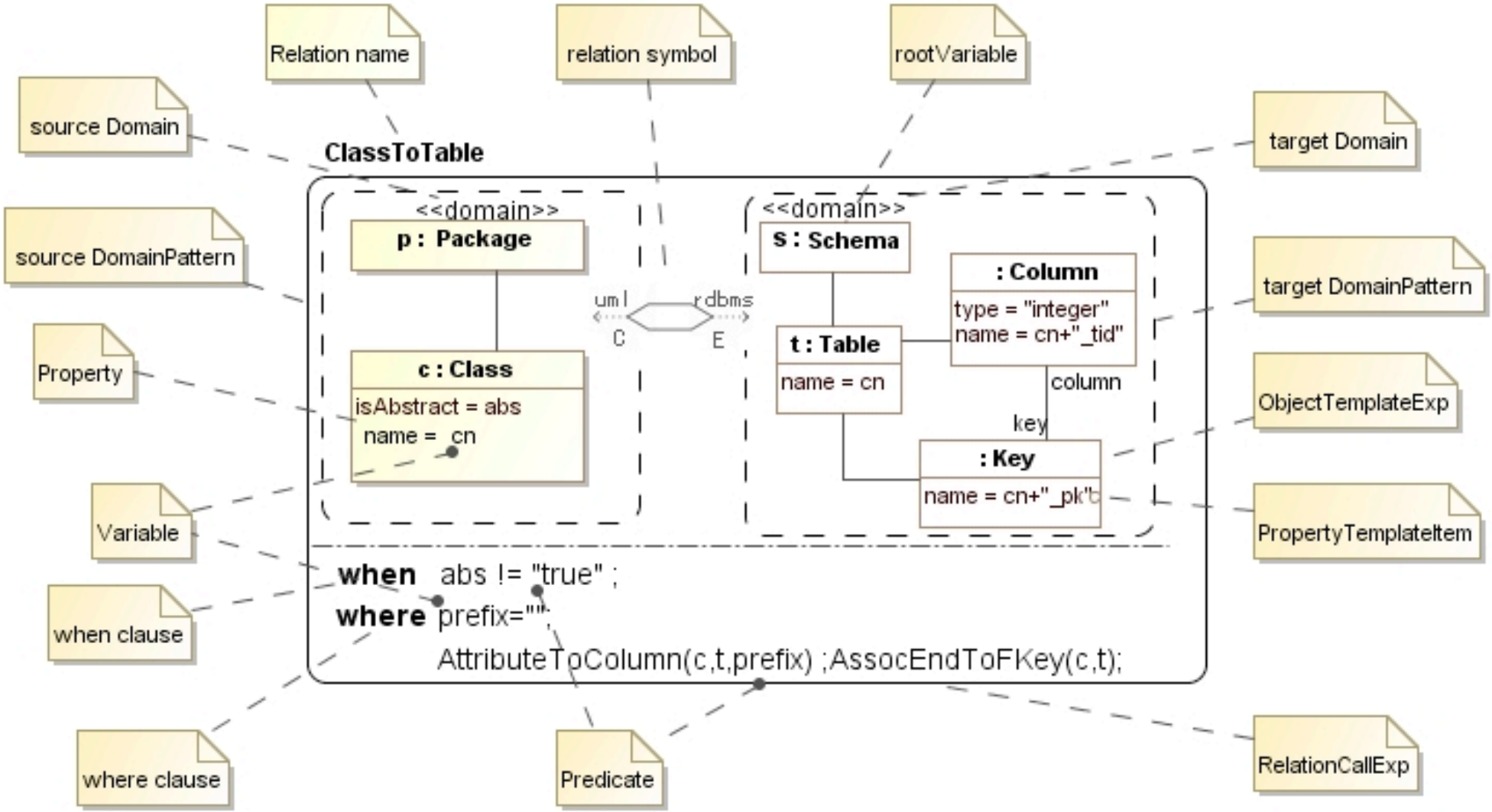
QVT Relations

- A declarative model transformation language with textual and graphical notation.
- A transformation is specified as a set of relations between model elements of source and target models.
- A relation specifies how two types of object diagrams, called domain patterns, relate to each other.
- Some support tools, but not for graphical notation.
  - Tata Consultancy *ModelMorf*
  - IKV++ medini QVT

QVTR in Graphical Notation

- Provides a concise, intuitive way to specify transformations.
- Graphical specification is a higher-level view that is easier to understand and communicate than the lexical counterpart.
- UML people might expect to continue the graphical tradition of class diagrams and favor a graphical notation
- A picture is worth a thousand words

A Relation in QVTR Graphical Syntax



XSLT

- Extensible Stylesheet Language for Transformations (XSLT) is one of the W3C standards.
- A declarative rule-based programming language for transforming XML documents
- Widely used in developing data-intensive applications
- An XSLT stylesheet consists of a set of rule templates
- Each rule template matches elements in source model, and produces output to the target model.

Why XSLT

- All major CASE tools can export (or import) model as XMI files;
- XSLT is the most common and powerful language for XML transformation;
- XSLT (Xpath) has strong support to complex pattern matching;
- XSLT has many industrial strength implementations, including commercial and open source tools, can also be embedded in Java;

Why XSLT (Cont.)

- Both QVTR and XSLT are declarative languages. Implementing QVTR as XSLT is done by mapping QVTR expresses to XSLT expresses.

- XSLT stylesheet s can be easily executed and integrated into different system environments and platforms, without additional packages and libraries.

An Example of XSLT Rule Template

```
<xsl:template match="packagedElement[@xmi:type='uml:Class' and
    not(@isAbstract='true')]" mode="ClassToTable">
        <xsl:variable name="c" select="current()"/>
        <xsl:variable name="cn" select="current()/@name"/>
        <xsl:variable name="prefix" select=""/>
        <xsl:element name="Table">
            <xsl:attribute name="name" select="$cn"/>
            <xsl:element name="Column">
                <xsl:attribute name="name" select="concat($cn,'_tid')"/>
                <xsl:attribute name="type" select="'integer'"/>
                <xsl:attribute name="key" select="concat($cn,'_pk')"/>
            </xsl:element>
            <xsl:element name="Key">
                <xsl:attribute name="name" select="concat($cn,'_pk')"/>
                <xsl:attribute name="column" select="concat($cn,'_tid')"/>
            </xsl:element>
            <xsl:apply-templates mode="AttributeToColumn" select="$c">
                <xsl:with-param name="prefix" select="$prefix"/>
            </xsl:apply-templates>
            <xsl:apply-templates mode="AssocEndToFKey" select="$c"/>
        </xsl:element>
</xsl:template>
```

Match Pattern

Rule Name

Variable Binding

Invoke Rules

Target Construction

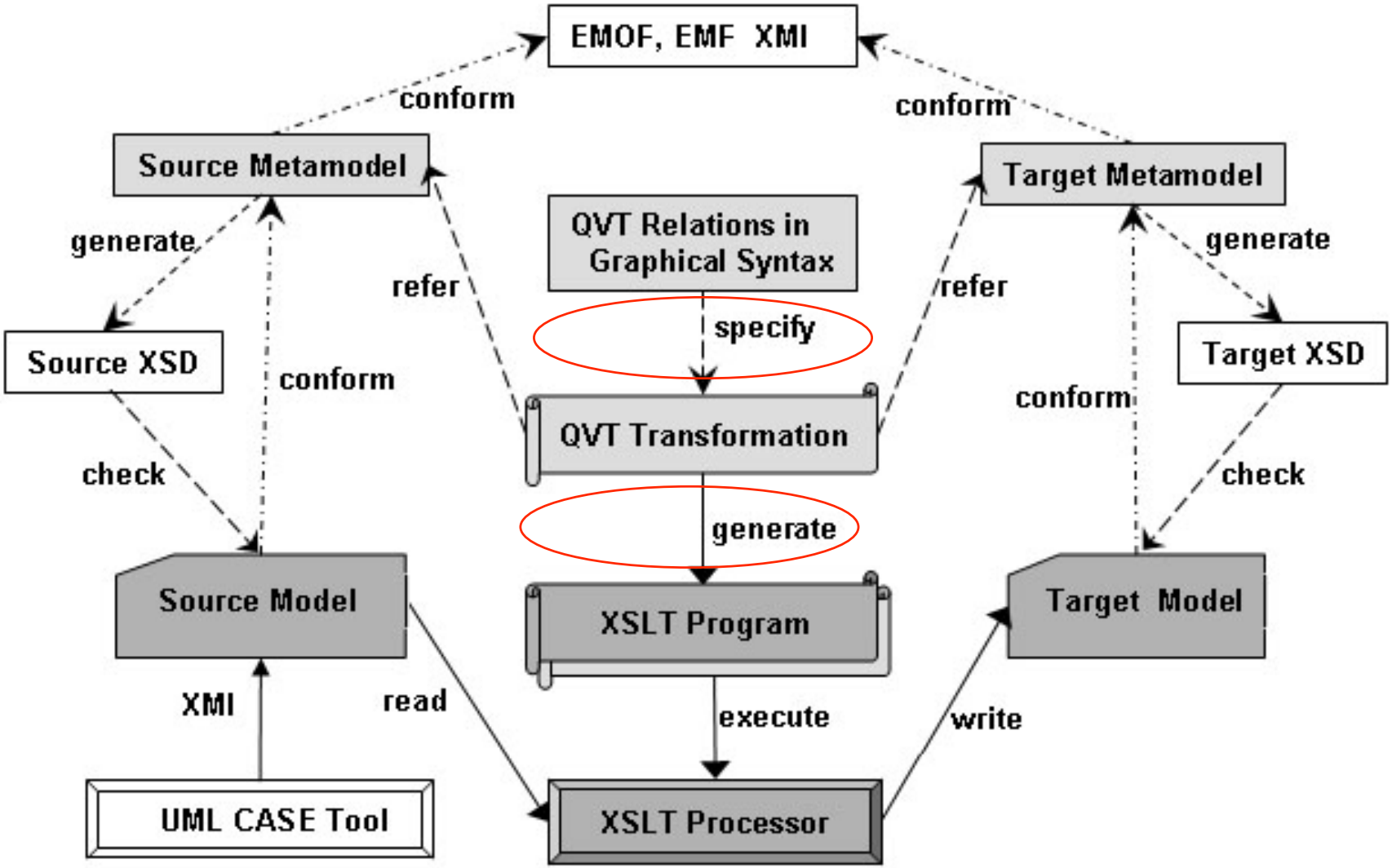
XSLT Cons

- Lower level of abstract
  - verbosity and poor readability of XML
- XSLT programming is different from other program languages
- Requires considerable effort to define complex model transformations directly using XSLT

Get the Best of Both Worlds

- Define the transformation using QVT Relations in graphical notation
- Mapping the transformation into XSLT
- Execute the XSLT program to transform the source model to target model

Approach Overview



QVTR-XSLT Tool

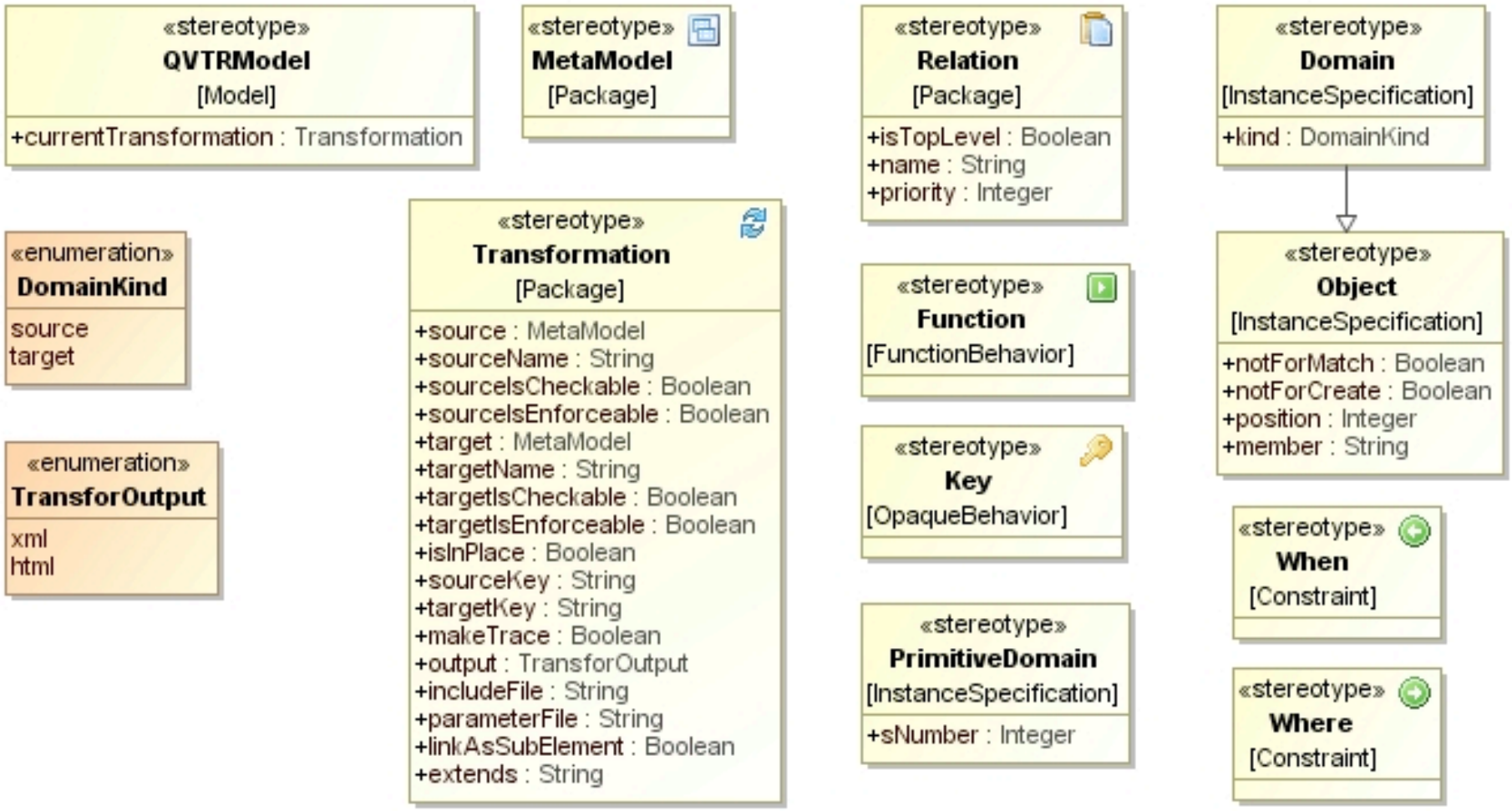
- A Graphical Editor
  - support design of QVTR transformations in graphical notation;
  - save the QVTR transformation models as XML files.

- A Code Generator
  - reads in the transformation model, generates corresponding XSLT stylesheets.

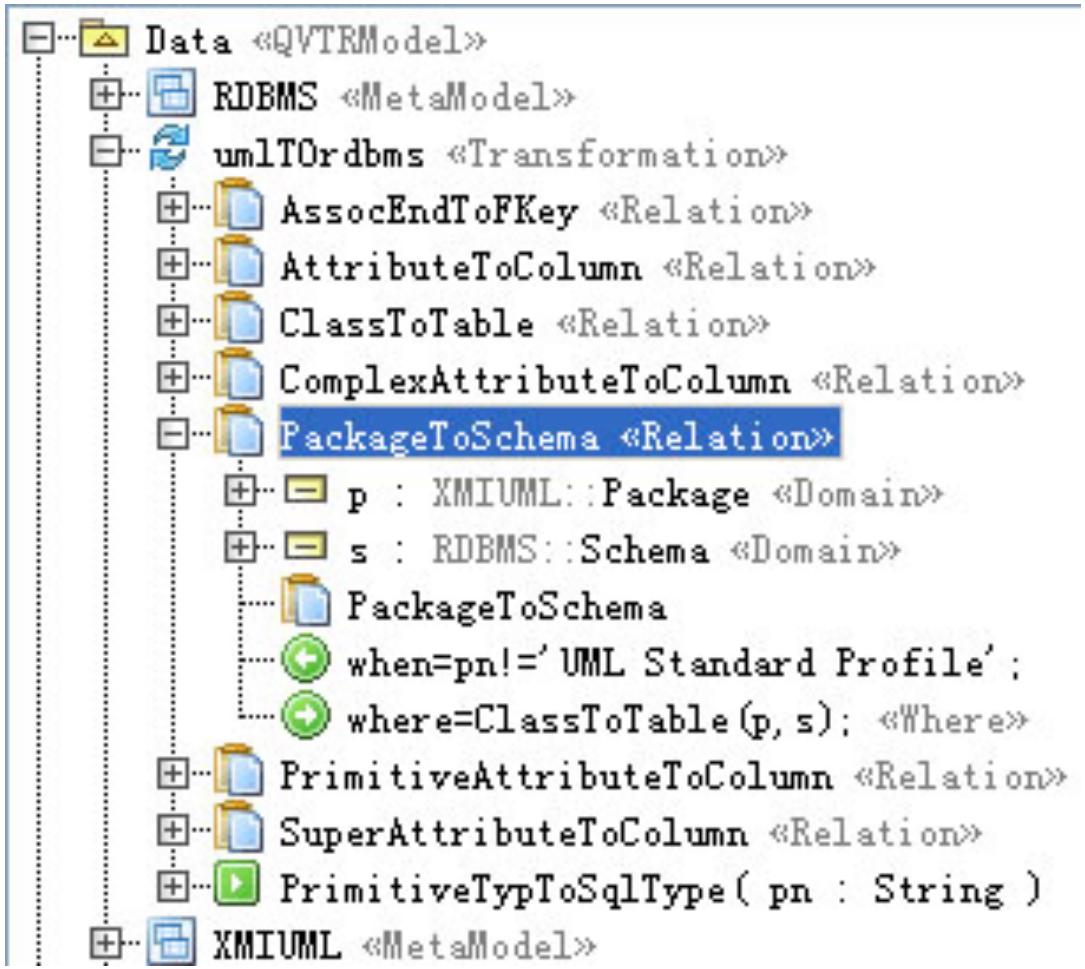
QVTR Graphical Editor

- Built on top of *MagicDraw UML* , a popular UML CASE tool;
- A UML profile to define QVTR transformation models;
- A toolbar to edit QVTR diagrams;
- A set of OCL rules to validate the transformation models.

UML Profile for QVTR Model



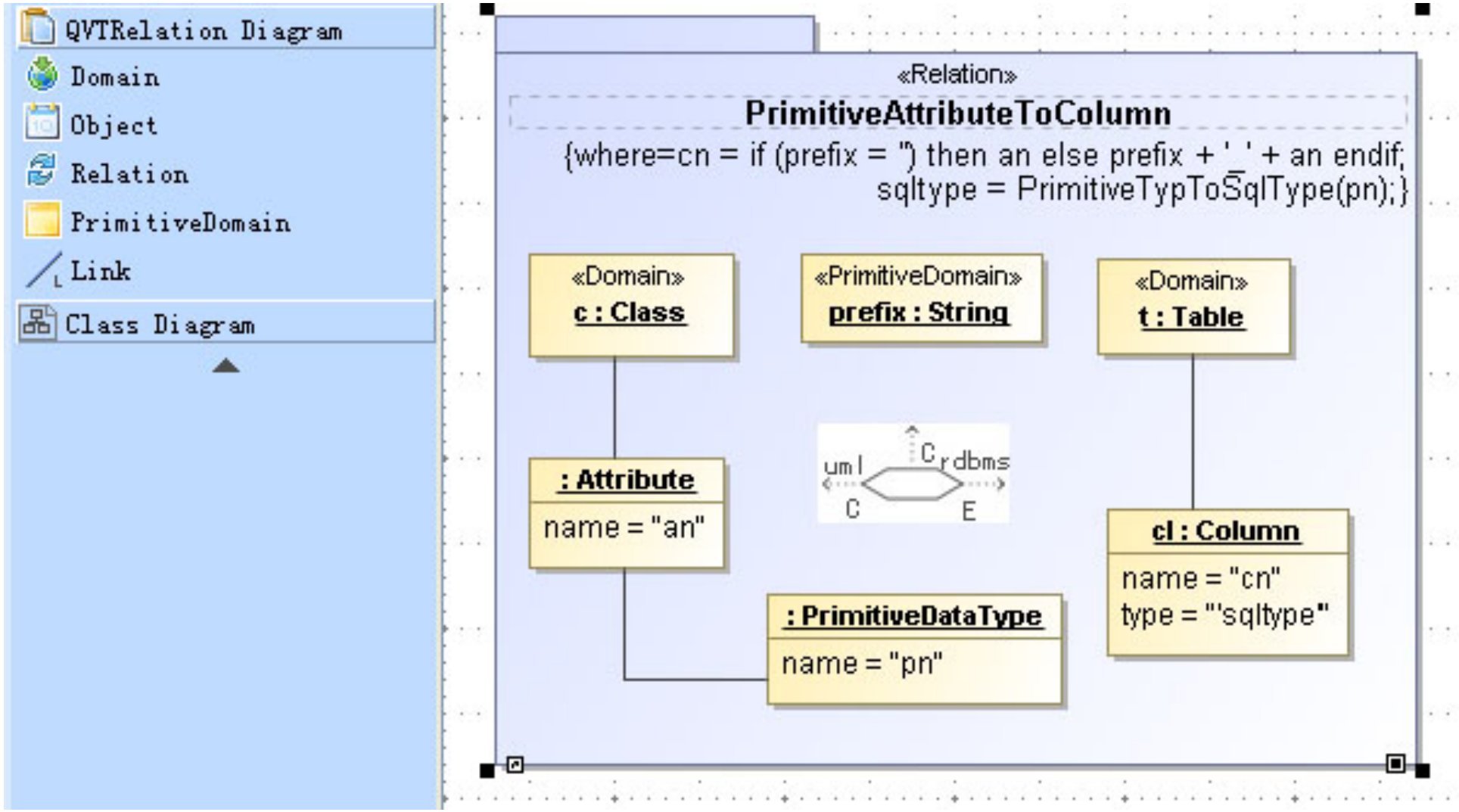
QVTR Transformation Model



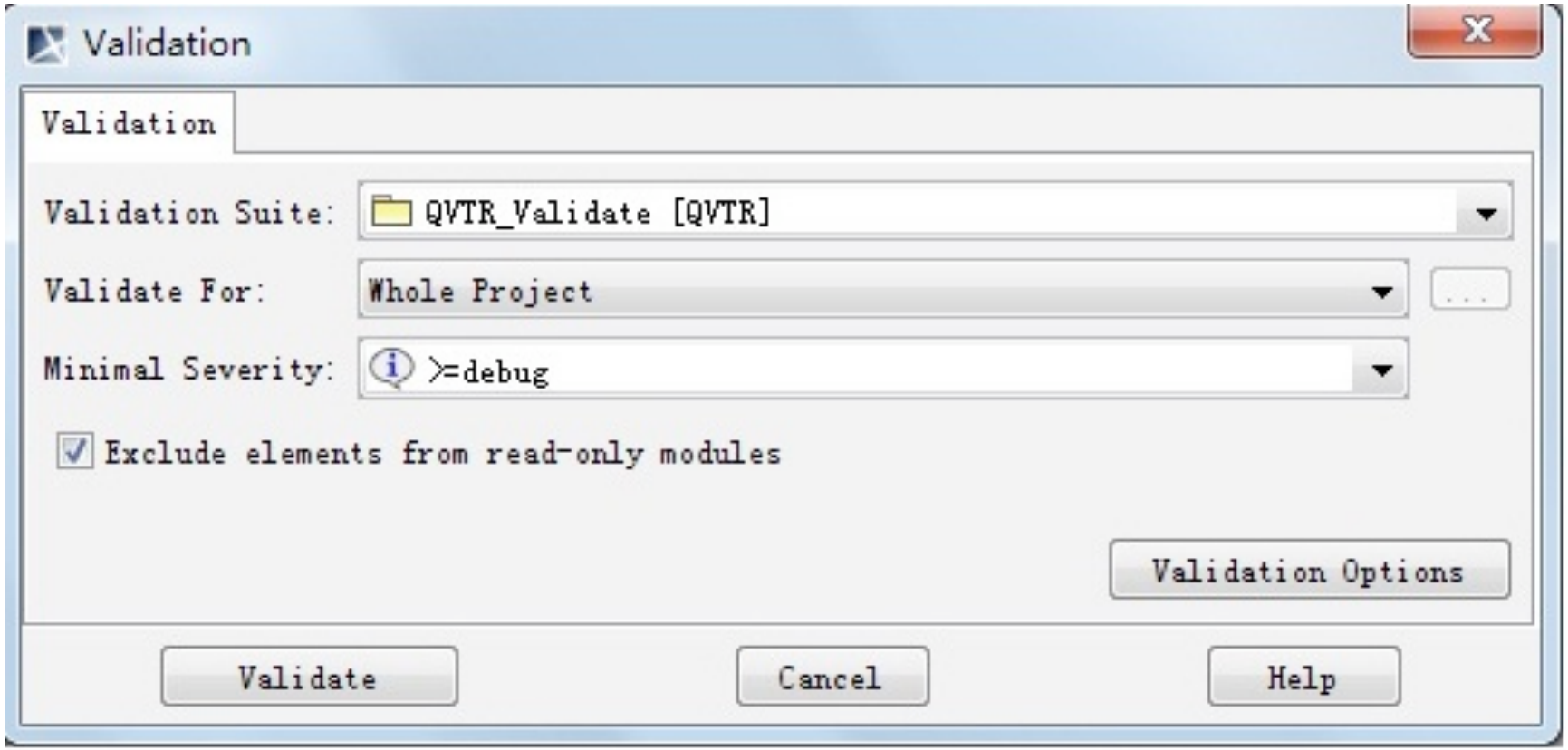
Consist of :

- MetaModels
  - classes, associations
  - ***class diagrams***
- Transformations
  - Relations
    - — Domains
    - — Objects and Links
    - — When clause
    - — Where clause
    - — ***QVTR diagram***
- Functions

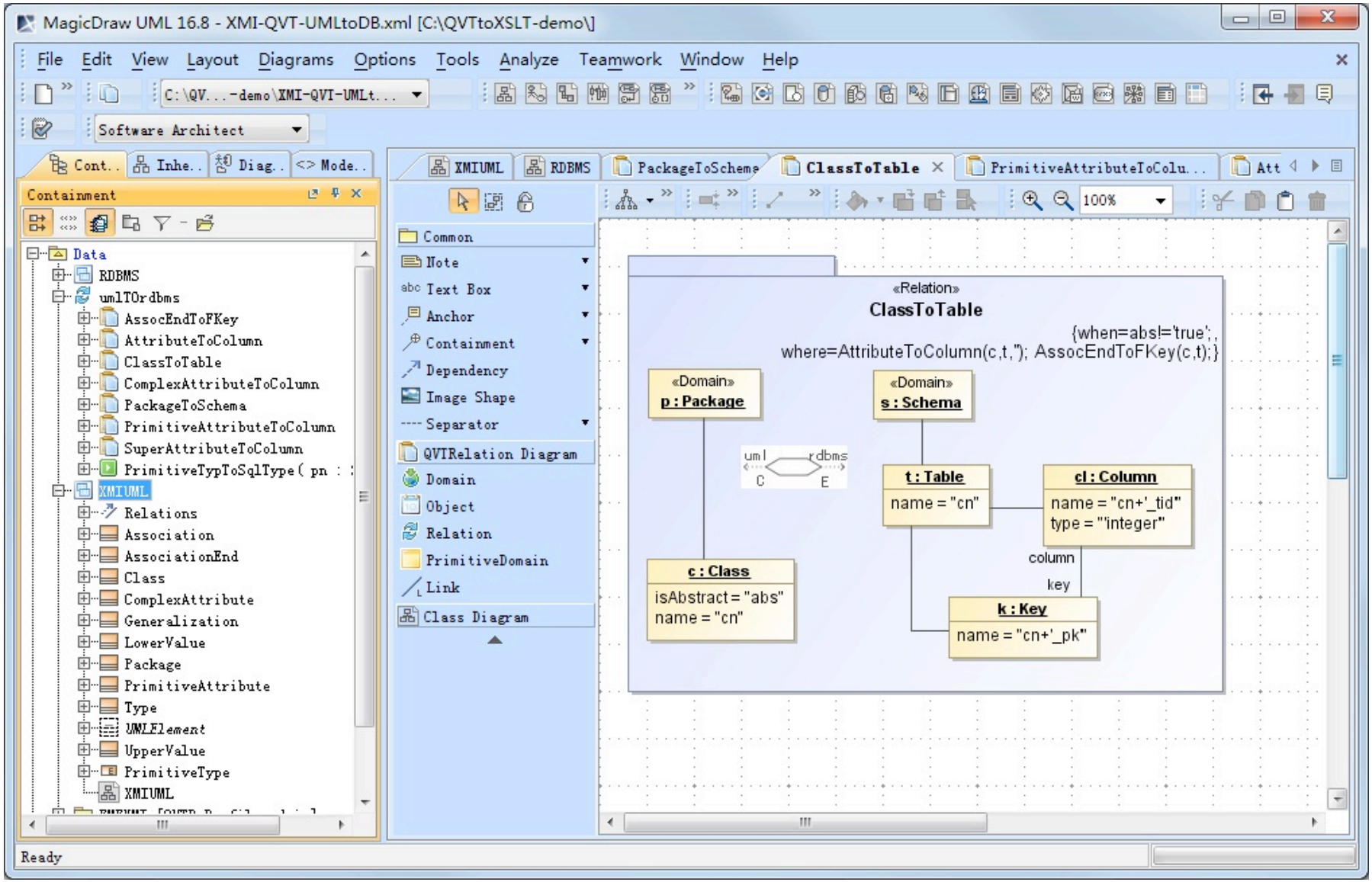
Toolbar for QVTR Diagram



QVTR Transformation Model Validation



Overall Interface of the QVTR Editor



Code Generator

- The generator itself is an XSLT stylesheet;
- It reads in the XML file saved from the transformation model, analyzes the model's structure, parses the OCL expressions, and generates an XSLT stylesheet that represents the QVTR transformation.

Mapping Transformation to Stylesheet

QVTR	***XSLT***
Transformation	*Stylesheet*
Relation	*Rule template*
Primitive domain	*Template parameter*
Function	*Function*
Key	*Key*
OCL expression	*XPath expression*

Mapping Relation to Rule Template

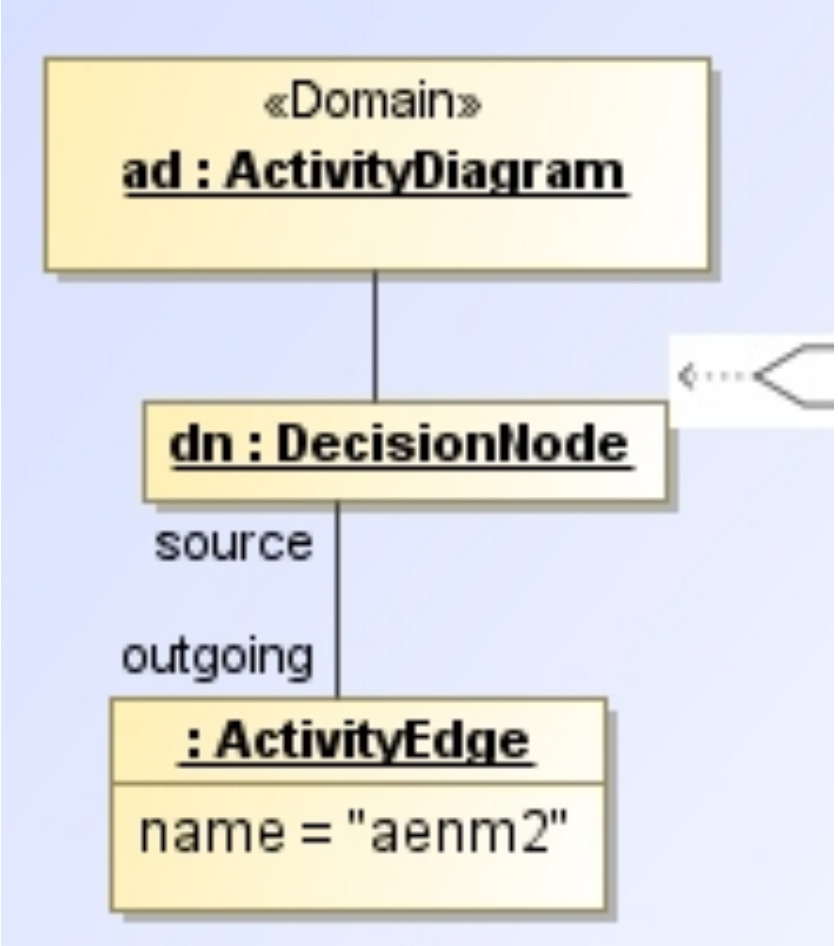
Relation

- Source domain pattern
  When clause
- Source domain pattern
  Where clause
- Target domain pattern
- Relation calls

Rule Template

- *Match expression*
- *Variable declarations*
- *Construction instructions*
- *Template calls*

Mapping OCL to XPath



OCL :

dn.outgoing->
  select(name='else')->size()=1

XPath:

count(my:xmiXMIrefs(current()/
@outgoing)[@name='else'])=1

Comparison - UML to RDBMS Example

- XSLT generated by the tool: 130 lines of code
- QVT relations in textual : 120 lines
- QVT operational: 100 lines
- QVT core : 400 lines
- MT : 140 lines
- medini QVT : 240 lines

Tool Features

- Unidirectional transformation;
- Single source model, target model creating ;
- Complex pattern matching of object templates, property templates, collection templates, and *not* templates;
- OCL expression referenced source domain pattern elements;
- In-place transformation;
- Transformation parameters;
- Transformation extensions (inheritance);
- Execution trace output;

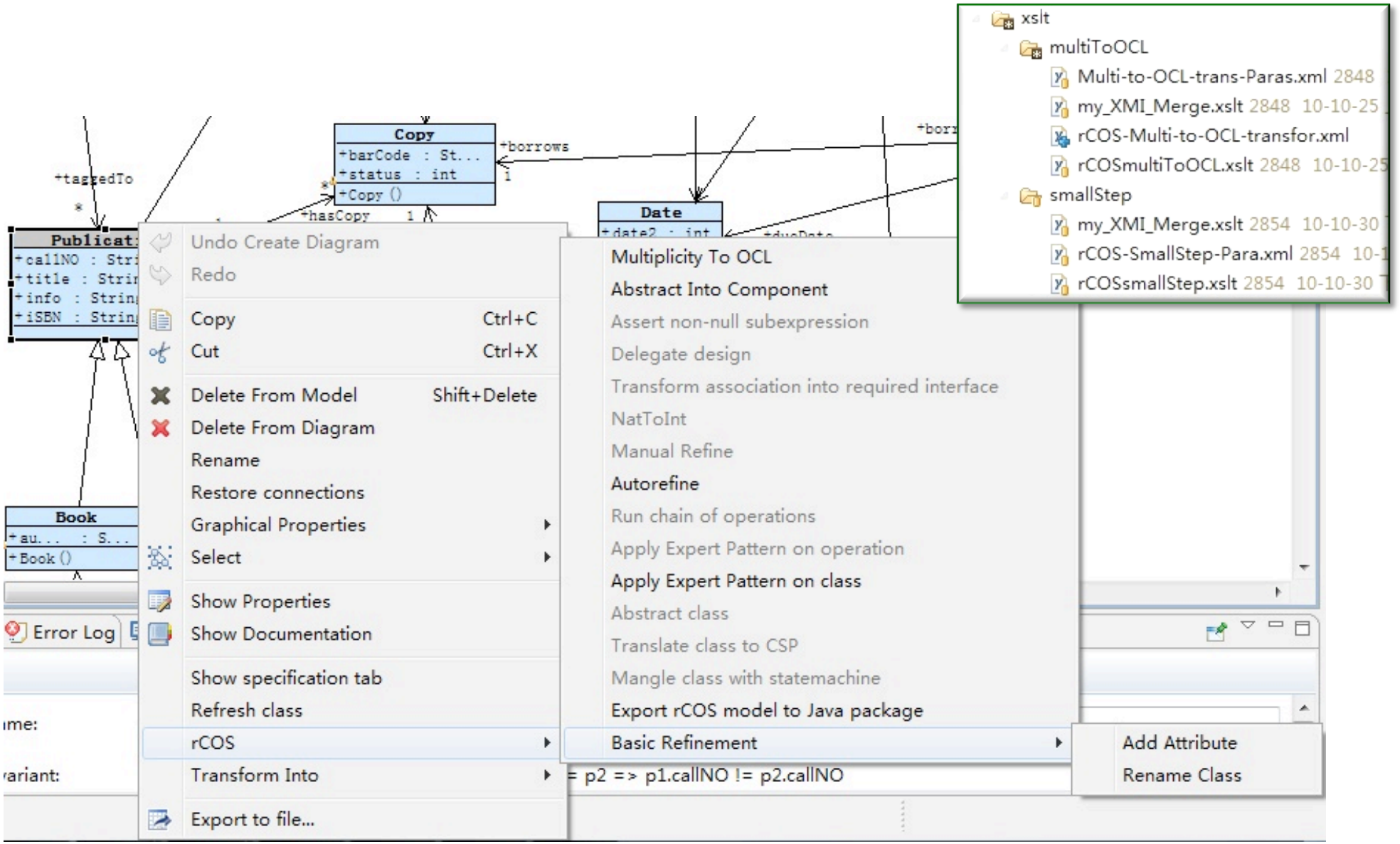
Potential Tool Users

- Model Community
  - A practical QVTR-compliance tool with graphical syntax support;
- XML Community
  - A higher-level XSLT generator with user-friendly IDE

Case Studies

- Model-to-Model
  - UML to RDBMS transformation
  - UML Activity Diagrams to CSP transformation
- Model-to-Text (Html)
  - CSP to Html transformation
  - RDBMS to SQL transformation
- In-Place
  - Multiplicity to OCL transformation
  - Small-step refinement

Integrate Transformation into CASE Tool



- **Thank You !**